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February 15, 2010

Response to NASA Commercial Reusable Suborbital Research Program (CRuSR) Request for Information

Solicitation NNA10CR001L

Modification – 28-Jan-11

Lynx Mark I with Dorsal Pod.

Introduction and Background

XCOR Aerospace, Inc. is pleased to respond to NASA Science Mission Directorate's Request for Information for the Scientist Participant Suborbital Science Pilot Program. We have been developing our recently-announced Lynx suborbital vehicle for several years, and it is based on two prior generations of human piloted rocket-powered vehicles. Lynx is designed to enable frequent, flexible, and affordable access to the space environment for scientists and/or their experiments, as well as the commercial human spaceflight market.

For commercial purposes, the Lynx is a small vehicle that will carry two people in a suborbital trajectory. This means that when a customer buys a ticket, they are actually buying an entire flight. This is a unique advantage for prospective scientific users of suborbital vehicles: they can obtain a flight dedicated to their mission needs at the cost of a single seat, rather than having to purchase a block of 4 to 8 seats on a larger, higher cost-per-flight vehicle.

Table 1. Synopsis of Payload Specifications

SPECIFICATIONS	LYNX MARK I	LYNX MARK II
Primary Payload Mass (w/o participant)	Internal: 120 kg External: 280 kg	Internal: 120 kg External: 650 kg
Primary External (Pod) Payload Dimensions (w/o participant)	43 cm diameter x 240 cm long	76 cm diameter x 340 cm long
Primary Internal Payload (w/o participant)	Standard 19" 14U rack: 41 cm depth; 2 Shuttle mid-deck lockers; or user provided enclosure	Standard 19" 14U rack: 41 cm depth; 2 Shuttle mid-deck lockers; or user provided enclosure
Secondary Internal Payload Mass & Dimensions (w/participant)	20 kg; 50 cm height x 46 cm bottom x 16.5 cm top	20 kg; 50 cm height x 46 cm bottom x 16.5 cm top
Aft Fairing Payload Mass & Dimensions	3 kg; 20 cm depth x 15 cm diameter	3 kg; 20 cm depth x 15 cm diameter
Power Available	28 VDC	28 VDC (can be augmented)
Pointing Accuracy	+/- 2 degrees	+/- 0.5 degrees
Minimum Turnaround Time	4 hours	2 hours
Nominal Apogee (assumes 120 kg internal payload)	>61 km (200,000 ft)	>100 km (330,000 ft)
Microgravity Time (10E-2 g)	56 seconds	186 seconds
Other Services	He, N_2, O_2	He, N_2, O_2, Optically flat window
Estimated price for various services	Ranges from $5K to $500K*, nominal $50 to $100K	Ranges from $5K to $500K*, nominal $50 to $100K

*Prices are provided for planning purposes only and are subject to negotiation based on special mission requirements and non-standard terms and conditions. The $5K price is for a small rideshare payload (secondary payload), while $500K is for a one-off standalone suborbital ballistic trajectory or LEO microsatellite launch using an expendable upper stage. Nominally, XCOR expects a science mission to cost between $50 to $100K, depending on the amount of support and level of integration required. "Plug-n-play" minimal XCOR involvement missions will be roughly $50K or so price level, while more labor intensive missions will push into, or above, $100K.

Company Point of Contact to acquire additional information

Please write or call Andrew Nelson (anelson@xcor.com, Mobile +1-617-899-8873) or Khaki Rodway McKee (khaki@xcor.com, XCOR's main phone number +1-661-824-4714 x122).

A. Flight Operations Information

(1) Planned start of commercial operations for payloads or passengers

The first Lynx flight test program (using Mark I prototype) is anticipated to start 2012 and expected to last nine to eighteen months, could carry suborbital research payloads. Commercial spaceflight participant (passenger) operations of Lynx Mark I will commence after completion of the flight test period. Flight of the first Mark II will follow approximately nine to eighteen months later depending on the prototype's advancement through the test program.

(2) How many passengers or payload spaces per flight

Lynx vehicles will have two (2) primary payload and three (3) secondary payload locations per flight. The vehicle's pressure cabin (Figure 1) will hold the *primary payload—right seat* and *secondary payload—aft of pilot seat*. External vehicle spaces (Figure 2) will have the *primary payload—dorsal pod*, and *secondary payload—port and starboard aft fairing ports*.

The *primary payload—right seat* can be a human in a pressure suit, two stacked Space Shuttle middeck lockers (MDLs), or a standard 19 inch electronic equipment rack. Both primary payload locations can not be occupied on the same flight, although all three secondary payload locations can be used along with a primary location.

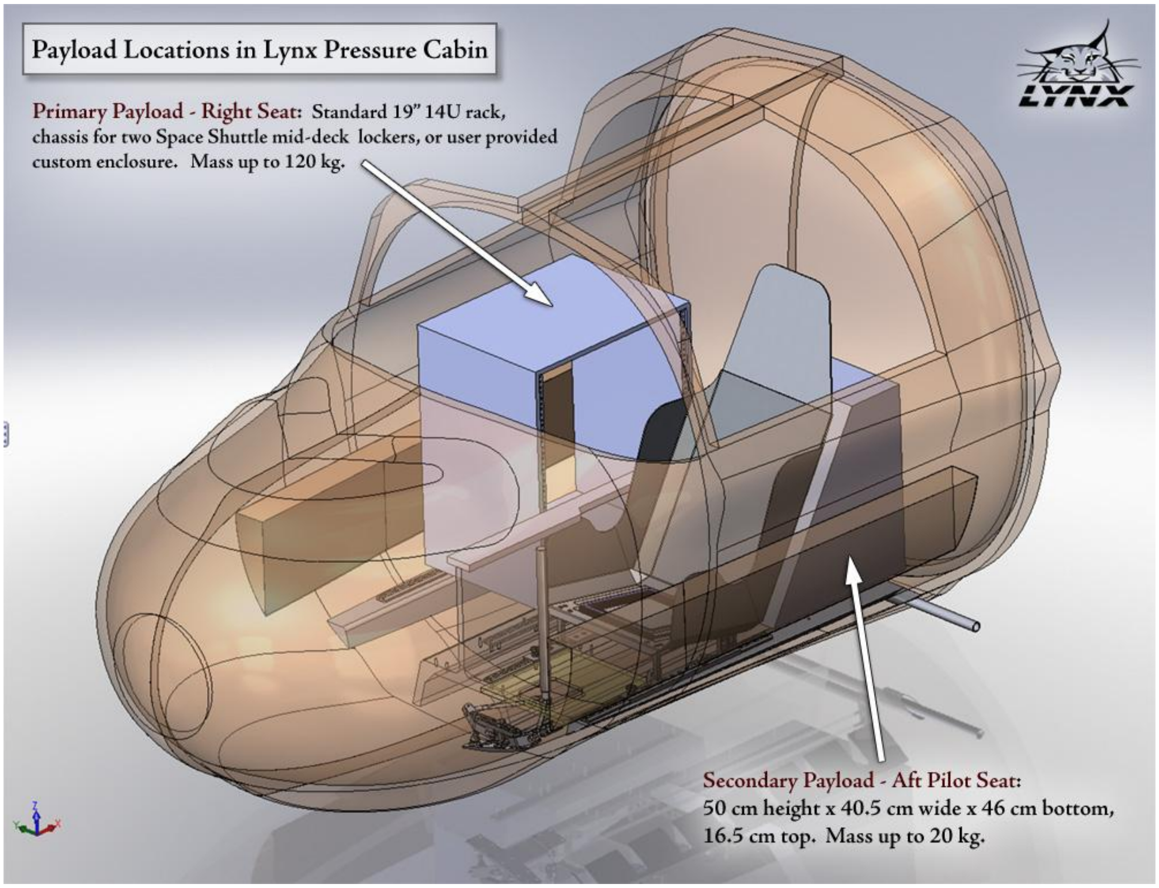

Figure 1. Payload Locations in Lynx Pressure Cabin

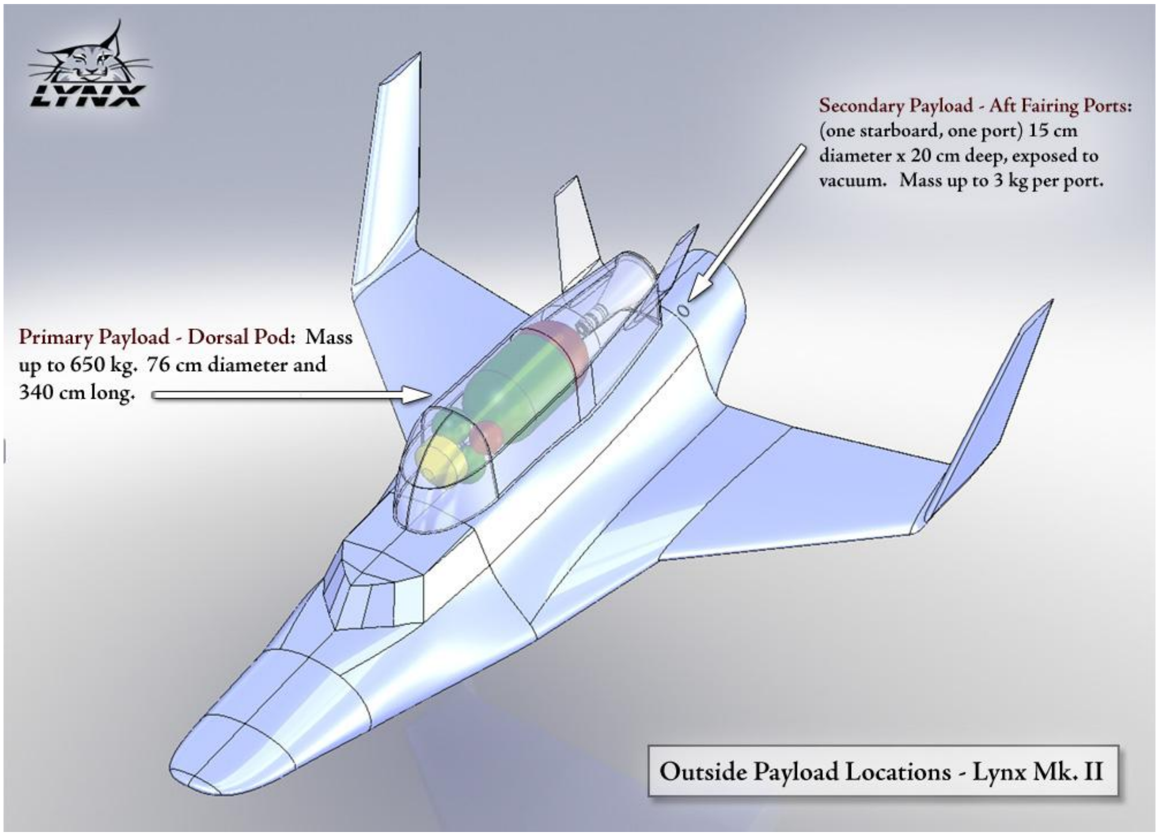

Figure 2. External Payload Locations, Lynx Mark II version shown.

(3) Planned frequency of flights

Operating tempo is assumed to be one flight per day in the first few months of the flight test program. However, XCOR expects this will gradually rise to three (3) per day (per vehicle) after one year in service and be up to four (4) per day during standard operations.

(4) Location(s) of launch and landing

Initial launch and landing site will be Mojave Air and Space Port in Mojave, CA. Under full operations Lynx will fly from any licensed spaceport with a 2100 meters (6890 ft) runway, such as Mid-Atlantic Regional Spaceport Virginia (MARS), Cape Canaveral (Florida), Spaceport America (New Mexico), Oklahoma Spaceport, etc. Lynx, as well as its ground support equipment and crew, are designed to be transportable on many standard cargo aircraft such as C-130, C-17 and C-5.

(5) Typical flight duration

Thirty (30) to forty-five (45) minutes for both Lynx Mark I and Mark II.

(6) Maximum flight altitude

Mark I, will fly to 61 km (200,000 ft). The Mark II will have enhanced capability and performance with the ability to attain 100 km (approximately 330,000 ft) altitude.

(7) Typical duration of microgravity

Mark I, will provide nearly one minute (56 seconds) of microgravity (below 10E-2 g). The Mark II will have almost three minutes (186 seconds) of microgravity (below 10E-2 g). Figures 3 and Figure 4 provide details.

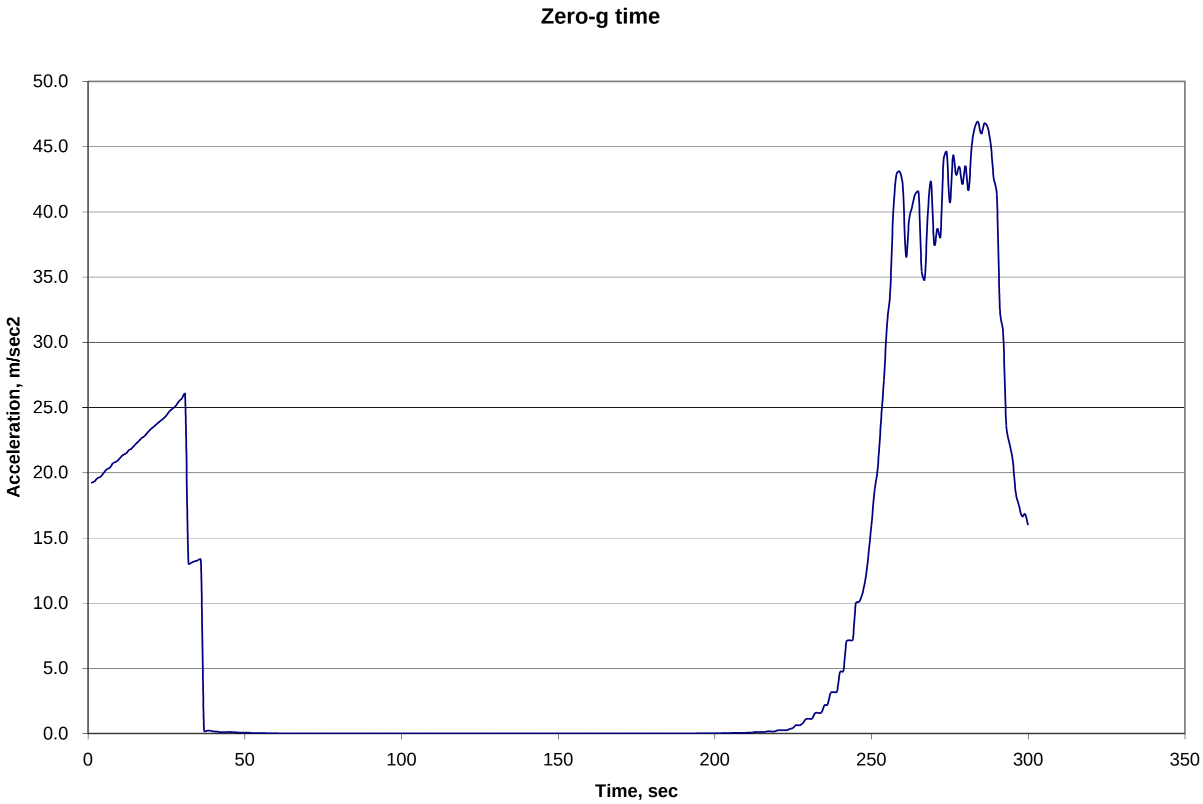

Figure 3. Lynx full mission profile for microgravity experiments.

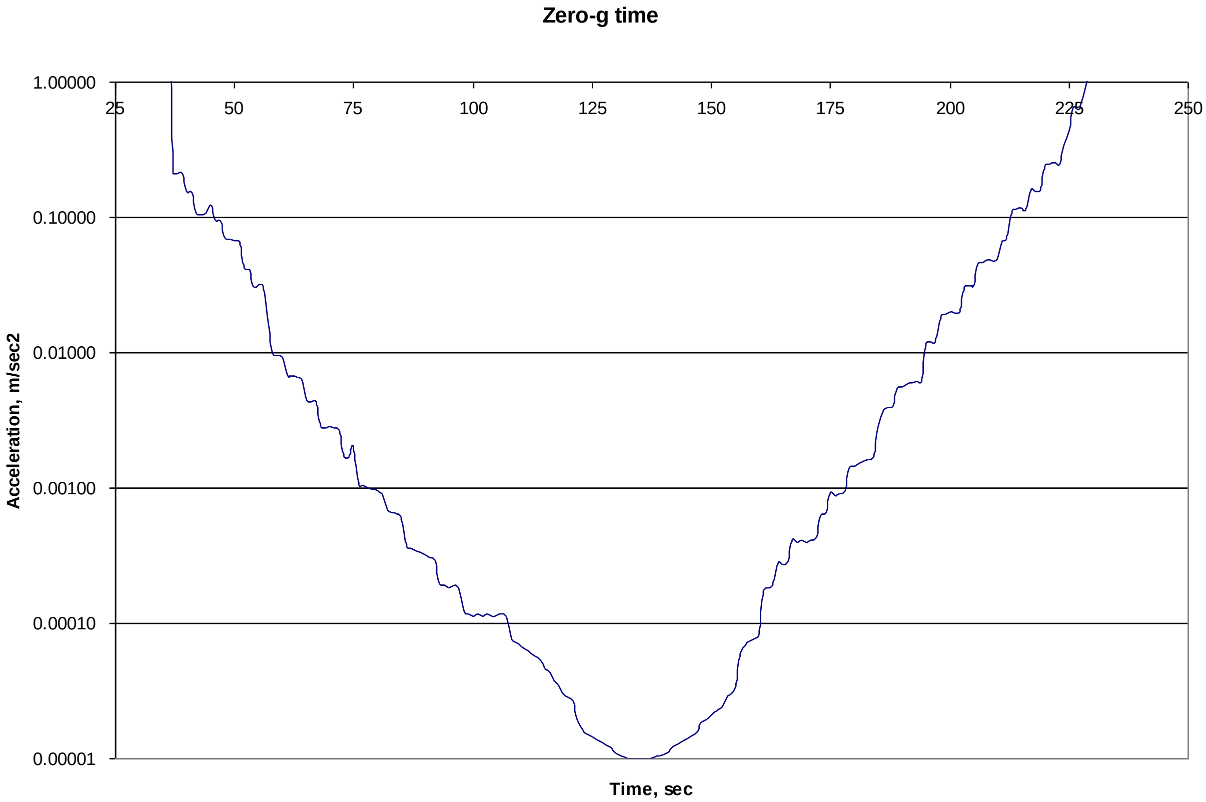

Figure 4. Tradeoff of acceleration versus time for Lynx.

B. Payload information

(1) Volume/dimensions available

<u>Internal locations (see Figure 1 above)</u>

Primary payload—right seat: With the passenger seat removed, the Lynx can accommodate a container 68.6 long x 50.58 wide x 53.3 cm high (Figure 3), such as two Shuttle mid-deck lockers. Total volume is estimated to be 0.17 m^3. Depending upon the weight of the payload, and its configuration, additional space could be made available.

Secondary payload—aft of pilot seat: This area can hold an irregularly-shaped container approximately 50 cm high x 46 cm at bottom x 55.9 cm high. It has a volume of slightly less than 0.09 m^3.

<u>External locations (see Figure 2 above)</u>

Primary payload—dorsal pod: Dimensions of the Mark II dorsal pod are 76 cm diameter x 340 cm long. The Mark I is 43 cm diameter x 240 cm long.

Secondary payload—port and starboard aft fairing ports: Each fairing port is 15 cm diameter x 20 cm deep. These cylindrical payload areas are exposed to vacuum. Volume is 3700 cm^3.

(2) Mass available

<u>Internal locations</u>
Primary payload—right seat: up to 120 kg (either passenger or payload).
Secondary payload—aft of pilot seat: up to 20 kg.

<u>External locations</u>
Primary payload—dorsal pod: Mark II up to 650 kg. Mark I up to 280 kg.
Secondary payload—port and starboard aft fairing ports: up to 3 kg per fairing port.

(3) Maximum vibration to design for

XCOR's liquid rocket engine tests have shown approximately <1% peak-to-peak of total thrust.

Acoustic levels inside Lynx during flight are similar to those inside other high performance aircraft. The high quality low acceleration time is bounded on both sides by medium accelerations suitable for sample melting and experiment thermal management. High acceleration loads (4.5 g^0) occur gradually (as in dive pullout) or on runway landing. Flight profile is shown in Figure 5.

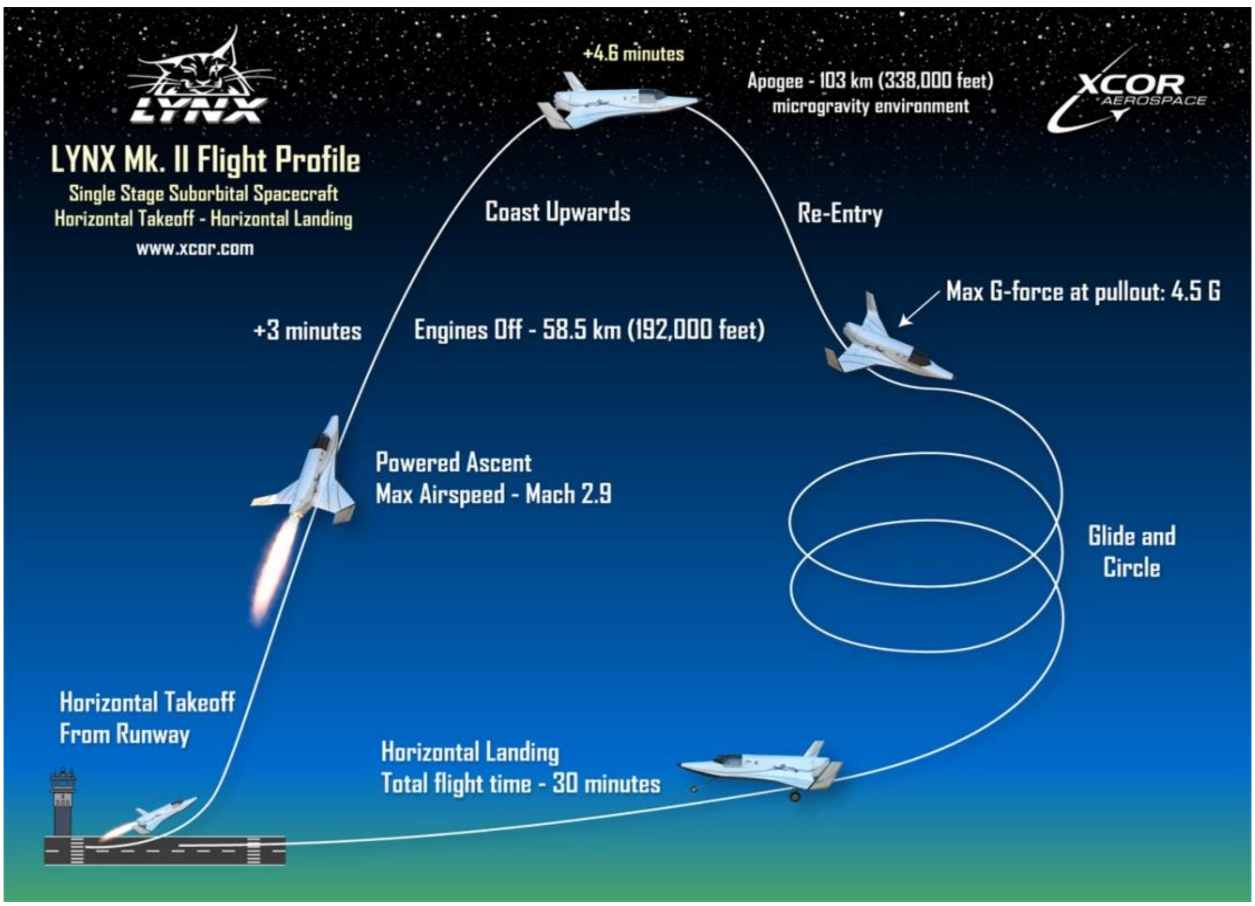

Figure 5. Lynx Suborbital Flight Trajectory Profile.

(4) Maximum g-load to design for: (i) Take-off (ii) Flight (iii) Landing (iv) Taxi

Lynx loads include a +3/-2 g0 limit envelope for the vehicle at maximum gross lift-off weight (GLOW) and a worst-case pullout envelope of +8g/-6 g0 at re-entry at maximum engine cutoff weight (MECO). Both cases load the structure to similar levels, and include effects of up to 50fps gusts. The GLOW envelope represents an instantaneous worst case condition immediately following takeoff. Allowable load factors increase rapidly during climb.

(5) Normal operating pressure and temperature

Cabin atmosphere is 10.5 psi +/- 0.4 psi synthetic air at low humidity, nominally 21% oxygen and 79% nitrogen. Partial pressure of oxygen in the cabin is continuously monitored.

Temperature is not provided.

(6) Payload access before and after flight

Yes. For internal payloads access will be through main entry doors on pilot and passenger sides of the vehicle. For external payloads, payload specialists will have hands on access at payload locations.

(7) Reduced gravity capability and quality of that capability (may be several levels)

See Figures 3 and 4.

(8) Access to environment external to the vehicle (e.g., open, optical through windows, sample ports,…)

The two aft fairing ports are exposed to environment. The dorsal pod has a nose door that may be opened in flight to expose a telescope or other optical sensor. The dorsal pod can also have windows designed into the structure, depending on the customer's willingness to fund the special development based on their specific needs.

C. Passenger information

(1) Maximum size or weight

This is 120 kg, which is the same for primary payload in the right seat.

(2) Training required/provided

Initial basic flight training of the payload specialist will be conducted by the same partner being used in our personal spaceflight training program, or by an acceptable alternate organization. Testing of the payload will be done as determined necessary by the analytical integration process.

(3) Access to payloads during flight

Not provided.

D. Special capabilities

(1) List other capabilities

- Preferred concept of operations for science flights

Vehicle operations for science flights will be little different from tourism flights, unless the experimenter requests a change. Examples of such changes could be high altitude pointing toward a chosen target, or attitude control to maintain a microgravity environment.

- Integration of science payloads/investigators/flights with other spaceflight participants/commercial flights (as applicable)

Since the vehicle has two seats total, a science mission will be a dedicated mission unless the payload is small enough to fly as a secondary payload with a commercial spaceflight participant or other science mission.

- Vehicle Power

Vehicle power is a nominal 28 VDC bus. Payloads can draw power from a dedicated pack of high discharge rate lithium batteries to provide higher current supply to the payload. This fully isolates experiments from the main vehicle busses.

- Payload to vehicle integration

<u>Internal locations</u>
Primary payload—right seat: will be attached to the right seat rails before the pilot's final briefing and secured with safety strap integrated in the Lynx airframe. All connections and data gathering apparatus will be tested before the vehicle is towed outside the hangar for fueling.
Secondary payload—aft of pilot seat: will be attached to the left seat rails behind the pilot's seat before the pilot's final briefing and secured with safety straps integrated in the Lynx airframe. All connections and data gathering apparatus will be tested before the vehicle is towed outside the hangar for fueling.

<u>External locations</u>
Primary payload—dorsal pod: will be loaded and secured in the dorsal faring before pilot's final briefing. All connections and data gathering apparatus will be tested before the vehicle is towed outside the hangar for fueling.
Secondary payload—port and starboard aft fairing ports: will be loaded in the aft fairing(s). All connections and data gathering apparatus will be tested before the vehicle is towed outside the hangar for fueling.

- Data rate for telemetry during ascent, coast, and descent phases, if available

Researchers should plan on-board data storage. Lynx can obtain 9.6kbit/second telemetry/command channel (phone line rate), which is sufficient for command events and "yes it worked/no it didn't" telemetry over that line, but not a high data rate. However, the vehicle and payload will return to launch site in approximately 30 to 45 minutes. Of course, if a client has a need for real time, high data rate telemetry, the non-recurring engineering and acquisition costs for such a capability can be priced separately.

- In-flight seating configuration and restraints

Pilot and spaceflight participant/payload specialist will have parachutes, pressure suits, and 5-point safety belts. Seating is side-by-side. Pilot (on the left side) is 15 cm forward of the participant/specialist.